

Bridge Deck Construction Process Review

PURPOSE:

The purpose of this review is to evaluate the adequacy of the (STA) Department of Transportation's (STA's) procedures for bridge deck construction. This review will focus on the entire bridge deck construction process from portland cement concrete mix design through curing and texturing. The main goal of this review is to determine if the current process adequately addresses the parameters necessary to successfully construct durable bridge decks.

An additional part of this review is to synthesize observations of procedures that appear to lead to bridge deck cracking. All types of cracking have the potential to prematurely shorten the life of a bridge's supporting members. Cost effective suggestions for eliminating preventable cracks will be made.

SCOPE OF REVIEW:

This review will consist of field assessment of concrete production, including plant operation, mixture control and material testing for cast-in-place bridge deck construction. The review will also evaluate delivery and placement control of the concrete as well as curing and texturing.

The review team will consist of the following members:

The review will include attendance at pre-pour conferences as time and resources permit. It will also include observation of "dry runs" which typically occur a day or two before the actual deck placement. Team members will then be on site during actual deck placement. The review itself will include visits to the concrete production plants as well as the bridge sites.

Interviews will be conducted with STA staff (or inspection consultants) both at the plant and at the job site. The purpose of these interviews is to determine if there are any problems with the current practices, guidance and specifications. Best practices will be summarized and presented at the statewide close-out meeting. Interviews will also be conducted with contractors and suppliers as appropriate.

Projects for this review will be selected statewide. However, STA districts that will be emphasized include Districts 1, 3, 6, and 8. At the completion of a District field review, a brief close-out meeting will be conducted to identify any issues that will be documented in the district report. The close-out meeting may be conducted with project staff and/or district staff as available. At this time, it is expected that district summary reports will be developed for each of the four selected districts. A district close-out meeting will be held at the end of the district review to discuss and resolve significant issues.

A final statewide close-out report will be developed at the end of this review which will document "best practices" as well as noted weaknesses. Unresolved issues will be addressed at the statewide close-out meeting which is expected to be conducted in September 1998.

Review of District-wide Bridge Deck Construction Procedures

1. Pre-Pour Conference:
 - A. How far in advance of a deck pour does this district typically conduct pre-pour conferences.
 - B. Is more than one pre-pour conference held?
 - C. Who attends pre-pour conferences? Whose responsibility is it to ensure that the proper people attend the pre-pour conference?
 - D. Is there a pre-pour conference checklist that the resident engineer uses to ensure that all items are discussed as necessary?

2. QC/QA Program:
 - A. What criteria does the district use to determine when a bridge deck project falls under the QC/QA program?
 - B. If a bridge deck is under the QC/QA program, is the project resident engineer completely familiar with his role versus the contractor's role relating to the control of materials and construction control?
 3. Pour Sequencing:
 - A. What is the procedure for determining the need for pour sequencing?
 - B. Does the Bridge Office design the pour sequence and provide it in the plans or is this coordinated after award of contract?
 - C. Does the resident engineers have the authority to modify or waive the pour sequencing or does the Bridge Office have to give final approval? How is this documented?
 4. Mix Design Procedures:
 - A. What is the district's procedure for developing a mix design for a particular bridge?
 - B. What involvement does the Central Office have in developing a mix design for a bridge deck?
 - C. Is a standard mix design used for all bridges in the district?
 - D. If standard mix designs are used routinely, what could trigger a change to the standard Acook book@ design?
 - E. If a contractor proposes a mix design, describe the review and approval process.
 - F. What procedures are used if the contractor proposes a modification to the approved mix design? What type of changes in the mix design do the project staff consider as significant enough to require additional review by other staff?
 5. Miscellaneous:
 - A. Does the district ever specify night-time pours?
 - B. Does this district have any experience with night time pours?
 - C. How much authority does the Resident Engineer feel he as when making calls on amounts of concrete additives, when to cure, when to adjust finishing machine, etc? (Distinguish between a QC/QA project versus a non-QC/QA project)
 - D. During the pouring of a bridge deck, does the district routinely have personnel from the District Bureau of Materials available to handle questions/problems about the concrete mix. Are they stationed at the deck site, concrete plant, or available by phone from elsewhere? Do they stay for the entire deck pour?
 - E. Obtain copies of a random sample of batch tickets. Calculate items such as w/c ratio, cement mortar factor, etc. and compare to mix design requirement.
 - F. What is the procedure that the State uses to decide whether to allow a contractor to proceed with a deck pour when weather forecasts are not entirely favorable?
 - G. What type of training is provided to a typical resident engineer prior to his/her first experience with a bridge deck construction project?
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Project Information:

STA District: _____ Project Location: _____

Contract Number: _____

Contractor: _____

Structure Number: _____

Structure Description: _____

Date of Concrete Placement: _____

Weather Conditions: _____

DETAILED REVIEW GUIDELINES

PRE-POUR ACTIVITIES

1. Project Staffing

- A. What is the construction inspection staffing for the deck placement operation? What is their experience?
- B. What is the materials inspection staffing? What is their experience?

2. Plant and Equipment

- A. Have weigh scales been approved by the Department of Agriculture? Are they operating within a maximum tolerance of 0.4 percent of the net load in the hopper (Section 1103.02)?
- B. What cement source does this plant use?
- C. What aggregate source does this plant use?
- D. What chemical admixtures (i.e. air-entraining, retarders, water-reducers, accelerators, etc.) are being used by the plant for this project?
- E. Do stockpile aggregates meet the gradation requirements (Section 1003.01, 1004.01)? What are the results?
- F. Are investigative samples being performed on fine and course aggregates at the frequency required by the Projects Procedures Guide? What are the results?
- G. Verify the following relative to the weighing equipment: Minimum scale graduation not more than 0.2% of the batch weight and not more than 0.1% of the capacity of the scale (Section 1103.02)?
- H. Is cement being weighed on a separate scale?
 - I. Is the cement and water being weighed within a tolerance of 1% of the required quantity and aggregates weighed (either separate or cumulatively) within a tolerance of 1.5 percent of the required quantity (Section 1103.03)?
- J. Is water flow automatically stopped at the correct amount?
- K. Are tubes that dispense air-entraining admixtures transparent or translucent to provide a visible indication that the admixture is actually entering into the batch? (Section 1103.03(a)(4))
- L. Do the scales zero consistently?
- M. Are the "tell-tale" dial and dial scale in full view of the operator?

3. Contract Special Provisions

- A. Be familiar with any special provisions pertaining to PCC concrete for the bridge deck.

4. Mixture Control

- A. What is the approved STA mix design? (Make a copy of the Proportioning Engineer's design data sheet)
 - B. Identify approved sources (aggregate and cement) for each specific mix design.
 - C. Does the mix design used match the approved design? Have there been any significant modifications to the mix proportions since the start of the project? If so, who approved the new mix design?
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Detailed Review Guidelines Pour Activities (Plant)

1. Mixing Requirements

- A. What is the sequence of mixing ingredients? (Article 1020.11)

Stationary Mixed Concrete - All water dispensed into the drum by the end of the first 15 seconds of the mixing period. Mixing time at least one minute for mixers having a capacity of 2 cubic yards or less and 75 seconds for mixers having a capacity of greater than 2 cubic yards.

Transit-Mixed Concrete - Not less than 60 nor more than 100 revolutions after all ingredients including water are in the drum when fine and coarse aggregates are charged simultaneously. Not less than 70 revolutions when fine and coarse aggregates are charged separately. The mixing operation begins immediately after the cement and water or the cement and wet aggregates, come in contact.

- B. Is the air-entraining agent introduced into the mixing water stream and fully discharged before all mixing water enters the drum? (Article 1020.08)
- C. Is retarder added for bridge deck concrete when air or concrete temperature is 65° F or higher? (Article 1020.05(b))
- D. Is all rinsing water discharged from the drum prior to batching?

2. Start Up Procedures

- A. Was an inspector available at the plant start up?
 - B. Is inspector knowledgeable of mix design requirements and adjustment procedures?
 - C. Are required tests performed properly with suitable testing equipment?
 - D. What tests were performed at the plant to ensure material mix control prior to shipping concrete to the jobsite (i.e. air, slump, gradations, moisture)?
 - E. Is the inspector able to communicate with the job site and determine mix performance with respect to material compliance, placement and finishing?
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Detailed Review Guidelines Pour Activities (Materials Control)

1. Revolution Requirements for Truck Mixers

- A. Is the batch counter on all arriving truck mixers immediately observed to ensure that the required number

of revolutions at mixing speed has been obtained? (N/A for Central Mix Plants)

B. What are the minimum and maximum revolutions? (Section IV, Proportion Manual)

2. Time of Haul

A. Is all concrete which is being hauled in truck mixers or truck agitators being deposited within 60 minutes without retarder and 90 minutes with retarder from the time stamped on the tickets? (1020.11(d)(8))

B. Is the delivery of concrete controlled to ensure continuity of concrete placement?

3. Concrete Temperatures

Are temperature checks of the plastic concrete being taken? The allowable limits for structural concrete are 50° F. to 90° F. When insulated forms or blankets are used: 50° F. to 80° F. (Article 1020.14(b)). When the temperature of the plastic concrete reaches 85° F. an approved retarding admixture shall be used or the approved water reducing admixture in use shall have its dosage increased by 50% over the dosage recommended by the Approved Admixtures list for the temperature experienced.

4. Air Content Determination

A. Is an air content test made on every load of delivered concrete and when mix water or air entrainment admixture is added at the job site? (Allowable air content: 5%-8%)?

B. Pumped concrete may lose air content in the pipelines. Measure the air content on the first four loads at the truck and at the discharge end of the line to determine air loss due to pumping. If the air content is on the low side or outside of specification requirements at the discharge end of the line, adjust the air on subsequent loads to compensate for the loss. Checks for air loss due to pumping should be repeated at quarter points of the pour or on a random basis to account for rising temperature and changing line lengths, etc.

C. What procedures do the contractor and/or inspector use if a load doesn't meet specifications?

5. Slump Test

Is a slump test made at least once each 50 cubic yards minimum or whenever mix water is added at the job site? (Allowable slump: 2" - 4")

6. Water/Cement Ratio Control

For bridge decks, how is the allowable job site water known by the Resident Engineer?

7. Adding Water or Admixture to Trucks at Job Site

A. Are the approved admixtures stored at the site or delivered daily? Is the storage adequate?

B. Compare actual admixture amounts with approved amounts.

C. If addition of admixtures is necessary at the job site, are the admixtures of the same brand as those used at the plant?

D. When water or admixtures are added to the ready-mix truck at the job site, is the concrete mixed 40 additional revolutions at mixing speed to assure proper mixing? Concrete that is modified at the job site after testing so as to alter test results significantly, should be retested for acceptance.

E. Is the Resident Engineer knowledgeable as to allowing additives at the job site?

F. Verify admixture compatibility and ensure that the application is in accordance with manufacturer's recommendations.

8. Strength Tests

Are either concrete test beams or cylinders being cast at the site of work and the following requirements met?

- A. Flexural Strength - 6 inch x 6 inch x 30 inch beams: Cast two beams per pour.
 - 1. Are the beams being made, cured, stored, and tested in accordance with specifications?
 - 2. Designed flexural strength > 675 psi in 14 days. (640 psi when mix contains fly ash, Article 1020.05 (c))
- B. Compressive Strength - 6 inch x 12 inch cylinders: Cast two cylinders in lieu of each beam.
 - 1. Are the cylinders being made, cured, stored and tested in accordance with the specifications?
 - 2. Design compressive strength > 4000 psi in 14 days (3800 psi when mix contains fly ash, Article 1020.05(c))

9. Concrete Delivery Tickets

- A. Are all truck tickets being collected and retained?
- B. Do concrete tickets show section number, time of batch, batch quantity, truck number, etc.?
- C. Are the inspector's initials, the results of air/slump tests, concrete temperature checks, time of discharge, water or admixtures added, drum revolutions of transit mix trucks recorded?
- D. Are all jobsite air, slump, water or admixture additions and beam test results being submitted to the proportioning technician daily for posting on MISTIC Form MI-654, Concrete, Air, Slump Quantity and Form MI-655, P.C. Concrete Strengths?

Detailed Review Guidelines Pour Activities (Construction Control)

1. Deck Preparation

- A. Are the forms clean and have they been properly treated prior to placement?
- B. Is the reinforcing steel adequately tied and supported? (50% intersections is allowed when spacing is less than 1 foot in each direction. Note: double ties required for lap splices at stage construction line when traffic is allowed on first completed stage deck during pouring of the second stage)

Chair Spacing: Bottom Bars - Continuous chairs at 3'3" max spacing

Top Bars - Continuous chairs at 3' max spacing or individual chairs at 2' x 3' max spacing

- C. Is the rebar clean and in good condition? Check damage to epoxy coating and evaluate touch-up procedures.
- D. Check fillets. (Any negative?)
- E. For decks with cantilevered forming brackets - are outside girders tied with #4 rebar at 4' centers if rail is outside water table or at 8' centers if rail is on exterior girders? (For P.C. I-beams, the ties should be spaced at a maximum of 8' regardless of where finishing machine rails are placed) Comment on tightness of ties. Some projects do not have this requirement with appropriate permission.
- F. Do tie bars have same clearance as bottom bars?
- G. Comment on storage and protections of epoxy coated reinforcing steel.

2. Production Rate

A. Calculate the actual production rate for the concrete pour and document here.

3. Placement and Consolidation

- A. Is the concrete being properly consolidated?
- B. Is there a sufficient number of vibrators on hand?
- C. Observe vibration at expansion angles or expansion joint blackouts. Comment on effectiveness.
- D. Are concrete drops less than 5 feet. If not, is a tremie being used?
- E. What is the frequency of depth checks for deck depth and rear cover? Was crown checked during dry run?
- F. If deck is skewed, what is position of the finishing machine and what is the angle of concrete placement?
- G. Observe laborers during concrete placement. Are they unnecessarily using rebar mats to clean their working and finishing tools (i.e. banging shovels, etc)

4. Finishing Machine

- A. Is finishing machine being operated on adjustable rails that do not deflect under the applied loads?
- B. Are the rails in place for the full length of the area to be finished?
- C. Are the no-weld areas (1/4 of span length from each pier) marked on the top flange of continuous span steel? (or otherwise identified?)
- D. Are support pipes welded (where permitted) with a 1/4 inch or less fillet weld continuously around the pipe? (Spot welding is not permitted) Are the supports that stay in place epoxy coated, galvanized or made of fiberglass?

5. Working Bridges

- A. Are two working bridges provided for finishing and curing?

6. Finishing

- A. If water is permitted by the Engineer, it shall be applied in a fine mist by means of a sprayer. Application by brushes or any other method that concentrates water will not be permitted. Comment on excessiveness.
- B. Is the surface being textured with either an astroturf or a burlap drag? Observe this operation and comment on microtexture.
- C. Are the edges of the freshly placed deck properly finished by hand?
- D. Is the contractor using long handled floats with short length blades (3 ft.) to float the entire surface of the deck? These floats should only be used when necessary to smooth and fill in open textured areas as these floats create bumps in the deck surface.
- E. If the contractor chooses to hand finish the entire deck, are the workers using 10 ft. long floats parallel to the bridge centerline and passing the float gradually over the deck surface filling depressions and cutting down high areas? Note: Although allowed, hand finishing should be kept to a bare minimum.
- F. If the contractor chooses not to hand finish the entire deck with a 10 ft. float, is he using a 10 ft. straightedge to check surface trueness? Is the handle not less than 3 feet longer than 2 the width of the slab? Observe closely the straightedging near expansion joints.

7. Curing

- A. What type of curing is being used?
- B. Is initial membrane curing used immediately after finishing and texturing? (Curing compound is to be applied immediately after the water sheen has disappeared from the surface and hand powered sprayers are not allowed.)
- C. Is the exposed rebar protected from the curing compound spray?
- D. Is the curing compound easy to see and is the application uniform? Curing compound should be placed in two separate applications at least one minute apart, each at the rate of not less than 1 gal. per 250 sq.ft.
- E. Check the source of the curing compound? Is it approved for use?
- F. Is the wetted burlap applied once the deck concrete obtains its initial set, is not easily marked and the membrane curing is dry?
- G. G. Is the top surface of the bridge floor being cured for 7 days but not more than 10 days with two layers of burlap being kept wet by means of a mechanical sprinkling system or with an impermeable covering (polyethylene)

8. Texturing

- A. Comment on the quality of mechanical grooving.
- B. Is the grooving stopped 12 inches from the face of the curblines?